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(54) INTEGRATED PRODUCTION OF UREA AND MELAMINE

INTEGRIERTE HERSTELLUNG VON HARNSTOFF UND MELAMIN

PRODUCTION INTÉGRÉE D'URÉE ET DE MÉLAMINE

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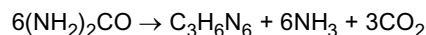
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Description**Field of the Invention**

[0001] The invention relates to the integration of urea and melamine production, in particular of urea and melamine produced according high-pressure liquid phase melamine technology. The invention also pertains to methods for re-vamping pre-existing urea and melamine plants.

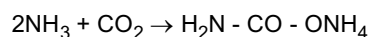
Background of the Invention

[0002] The integration of urea and melamine production has long been known. Melamine is thereby produced from urea, according the following reaction:

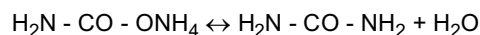


[0003] Interestingly, ammonia and carbon dioxide result from this process in precisely in the stoichiometric ratio from which these substances form urea.

[0004] The latter is generally presented in the form of two consecutive reaction steps. In the first step, ammonium carbamate being formed according to the exothermic reaction:



[0005] Thereafter the formed ammonium carbamate is dehydrated in the second step to give urea according to the endothermic equilibrium reaction:



[0006] In the art, urea plants are generally filled with starting materials on the basis of an excess of ammonia (i.e. above the 2:1 stoichiometric ratio). These reactants are subjected to a pressure between 12 and 40 MPa and a temperature between 150°C and 250°C in a urea synthesis zone.

[0007] In the integrated production of urea and melamine, urea produced in a urea synthesis zone is sent to a melamine synthesis zone. The carbon dioxide and ammonia off-gas resulting from the melamine production is, in turn, recirculated as a starting material for use in the urea synthesis zone.

[0008] It will be understood that, irrespective of the excess of ammonia introduced, the reactants are drawn from the synthesis zone in not more than a 2:1 ratio, and the off-gas from the melamine synthesis thus reintroduces the urea-forming reactants in the same ratio. Thus, the ammonia to carbon dioxide ratio in the entire urea and melamine synthesis and recirculation loop remains the same.

[0009] The integrated production can take place in an integrated plant, having urea and melamine synthesis zones. More typically, however, the melamine and urea synthesis zones are comprised in separate plants for the production of urea and melamine, which plants are coupled using the appropriate flow lines so as to realize the aforementioned integration.

[0010] A typical urea plant is a urea stripping plant. Therein, the decomposition of the ammonium carbamate that has not been converted into urea and the expulsion of the usual ammonia excess largely takes place at a pressure that is essentially almost equal to or lower than the pressure in the synthesis reactor. This decomposition and expulsion take place in one or more stripper(s) installed downstream of the reactor, possibly with the aid of a stripping gas such as, for example, carbon dioxide or ammonia, and with the addition of heat. The gas stream leaving a stripper contains ammonia and carbon dioxide which are condensed in a high-pressure condenser, operating at essentially equal pressure to the pressure in the stripper and then returned to the urea synthesis zone.

[0011] In a urea stripping plant the synthesis zone is operated at a temperature of 160 - 240 °C and preferably at a temperature of 170 - 220 °C. The pressure in the synthesis reactor is 12 - 21 MPa, preferably 12.5 - 20 MPa. The ammonia to carbon dioxide molar ratio (N/C ratio) in the urea synthesis zone of a stripping plant lies usually in between 2.2 and 5 and preferably between 2.5 and 4.5 mol/mol. The synthesis zone can be carried out in a single reactor or in a plurality of reactors arranged in parallel or series.

[0012] After the stripping treatment, the pressure of the stripped urea solution is reduced in a urea recovery section (or recirculation section, as from this section carbamate is recirculated). In a recovery section the non-converted ammonia and carbon dioxide in the urea solution is separated from the urea and water solution. A recovery section comprises usually a heater, one or more liquid/gas separation sections and one or more condensation sections. The urea solution entering a recovery section is heated to vaporize the volatile components ammonia and carbon dioxide from that solution.

The heating agent used in the heater is usually steam. The formed vapor in said heater is separated from the aqueous urea solution in the liquid/gas after which said vapor is condensed in the condenser to form a carbamate solution. The released condensation heat is usually dissipated in cooling water. The formed carbamate solution in that recovery section operated at a lower pressure than the pressure in the synthesis section is preferably returned to the urea synthesis section operating at synthesis pressure. The recovery section is generally a single section or can be a plurality of recovery sections arranged in series.

[0013] In a urea stripping plant operating with carbon dioxide as a stripping gas, it is normally advantageous to introduce substantially all of the carbon dioxide into the synthesis loop via the stripper. In the event of the integrated production of urea and melamine, however, part of the carbon dioxide feed is determined by the recirculation of the off-gas of the melamine production. Since this off-gas contains both carbon dioxide and ammonia, it is less suitable to be used as a stripping medium, as using it would not result in a decrease of the partial pressure of only one if the components in the liquid phase.

[0014] With part of the carbon dioxide reactants thus being introduced elsewhere into the urea synthesis section, the carbon dioxide feed to the stripper will be necessarily reduced as compared to a urea plant operating on a stand-alone basis, i.e., without being integrated with the production of melamine. This results in a less efficient operation of the stripper. Whilst this could be offset by increasing the stripping temperature, the latter results in a higher overall energy consumption of the plant, typically in the form of a higher steam requirement (steam being used at the shell-side of the stripper to supply heat). Also, adding more heat to the stripper can only be done by increasing the stripper temperature. However this is limited because higher temperatures decrease the corrosion resistance of the materials from which such strippers are generally fabricated. Accordingly, increasing the stripper temperature increases corrosion, which may cause damage to said stripper, thereby reducing the lifetime thereof.

[0015] The invention seeks to provide integrated urea and ammonia production allowing stripping efficiency, steam consumption, or both, to be optimized.

[0016] This has not been adequately addressed in the art, despite a vast number of disclosures regarding various ways of integrating the production of urea and melamine. As examples reflecting the state of the art, reference is made to the following documents.

[0017] In WO98/08808 A1 a process for the integrated production of urea and melamine is illustrated in the block diagram as given in Fig. 2. In the known process, a gas stream originating from a high pressure process for the preparation of melamine is supplied directly to a high pressure section of a stripping process for the preparation of urea. A disadvantage of the known method is that stable operation of the resulting combined process for the preparation of melamine and urea is difficult: pressure fluctuations in one of the processes can easily affect the other process via the gas stream and thus result in unstable operation and process disorder. Another disadvantage is that the best operation of the known method is achieved if the melamine process has a higher pressure than said high pressure section of the urea process. As mentioned the energy consumption of the urea plant that processes the off-gas of an integrated melamine process increases in relation to a stand-alone urea plant. More specifically, as explained above, the energy consumption increases if the urea plant is a carbon dioxide or ammonia stripping plant type.

[0018] Another method is disclosed in US 7,893,298 B2 and is illustrated in the block diagram as given in Fig. 4. In the known process, a gas stream originating from a high pressure process for the preparation of melamine is condensed in an aqueous ammonium carbamate stream that has been formed in a CO₂ stripping process for the preparation of urea.

[0019] Yet another method is disclosed in WO 2008/052640 A1. In this known process the urea plant contains a medium pressure treatment section including a decomposer. A gas stream from melamine production is fed, together with vapor as formed in said decomposer and with the aqueous ammonium carbamate solution as formed in a downstream urea recovery section, to a condenser of the medium pressure treatment section. This results in a concentrated aqueous carbamate solution that is recycled to the high pressure urea synthesis section.

[0020] The invention seeks to reduce the steam consumption of a urea plant, after being integrated with a melamine plant. Alternatively, the invention seeks to keep the steam consumption for the urea production section in an integrated urea and melamine plant at least equal. All in all, the invention thus seeks to increase the economics and functionality in a facility for the integrated production of urea and melamine.

Summary of the Invention

[0021] In order to better address one or more of the foregoing desires, the invention, in one aspect, provides a process for the integrated production of urea and melamine, the process comprising subjecting carbon dioxide and ammonia to urea forming conditions in a urea production zone comprising a reactor and a stripper, so as to form a urea synthesis stream comprising urea, water and ammonium carbamate; subjecting the urea synthesis stream to processing so as to obtain an aqueous urea stream and a vapor comprising ammonia, carbon dioxide, and water, wherein said processing comprises stripping in said stripper; feeding urea to a melamine production zone; subjecting the urea fed to the melamine production zone to melamine forming conditions so as to form melamine and melamine off-gas comprising carbon dioxide

and ammonia; feeding the off-gas to the urea production zone; subjecting the vapor and the melamine off-gas to combined condensation in indirect heat exchange with the aqueous urea stream; forming a combined stream of the condensate of the vapor and the condensate of the off-gas, so as to provide a dilute melamine off-gas condensate, and using said dilute melamine off-gas condensate as a fluid in said indirect heat-exchange.

[0022] The invention also provides a facility for the integrated production of urea and melamine, said facility comprising a urea production zone and a melamine production zone; the urea production zone comprising a urea synthesis section comprising a reactor and a stripper, and a carbamate recirculation section comprising an inlet for stripped aqueous urea solution and a liquid/gas separation section; the melamine production zone comprising a melamine synthesis section and an off-gas separation section; said facility comprising a fluid transport line from the urea production zone to the melamine production zone, said line being suitable for feeding formed urea to the melamine synthesis section, a gas flow line from the off-gas separation section of the melamine production zone to the urea synthesis section, said gas flow line being in communication with a gas inlet of a condenser for melamine off-gas, said condenser comprising a liquid outlet for condensed gas, and a gas flow-line for vapor from the liquid/gas separation section in fluid communication with said condenser, wherein said condenser for melamine off-gas and for said vapor is comprised in a condensation system.

[0023] In yet another aspect, the invention provides a method for reducing the energy consumption of a urea production zone of a pre-existing facility for the integrated production of urea and melamine, said facility comprising a urea production zone and a melamine production zone; the urea production zone comprising a urea synthesis section comprising a reactor and a stripper, and a carbamate recirculation section comprising an inlet for stripped aqueous urea solution and a liquid/gas separation section; the melamine production zone comprising a melamine synthesis section and an off-gas separation section, the method comprising adding a concentrator to the urea production zone, said concentrator comprising an evaporation chamber for liquid to be heated and evaporated, said evaporation chamber comprising a gas outlet for evaporated liquid and being in heat-exchanging communication with a chamber for indirect heat exchange; providing a transport line for liquid feed from the liquid/gas separation section of the urea plant to said evaporation chamber; providing a gas flow-line from the liquid/gas separation section of the urea plant to a condensation system, said condensation system comprising a liquid outlet in fluid communication with the chamber for indirect heat exchange; and providing a gas flow-line from the off-gas separation section of the melamine production zone to the condensation system, wherein said condensation system is configured for subjecting the vapor from the liquid/gas separation section of the urea plant and the melamine off-gas to combined condensation in indirect heat exchange with the aqueous urea stream. In a further aspect, the invention provides a method of increasing the plant capacity of the melamine production zone of a pre-existing facility for the integrated production of urea and melamine, said facility comprising a urea production zone and a melamine production zone; the urea production zone comprising a urea synthesis section comprising a reactor and a stripper, and a carbamate recirculation section comprising an inlet for stripped aqueous urea solution, wherein the urea synthesis zone comprises a reactor and a stripper, and wherein the carbamate recycle section comprising and a liquid/gas separation section; the melamine production zone comprising a melamine synthesis section and an off-gas separation section, the method comprising expanding the melamine synthesis capacity of the melamine synthesis section; adding a concentrator to the urea production zone, said concentrator comprising an evaporation chamber for liquid to be heated and evaporated, said evaporation chamber comprising a gas outlet for evaporated liquid and being in heat-exchanging communication with a chamber for indirect heat exchange; providing a transport line for liquid feed from the liquid/gas separation section of the urea plant to said evaporation chamber; providing a gas flow-line from the liquid/gas separation section of the urea plant to a condensation system, said condensation system comprising a liquid outlet in fluid communication with the chamber for indirect heat exchange; and providing a gas flow-line from the off-gas separation section of the melamine production zone to the condensation system, wherein said condensation system is configured for subjecting the vapor from the liquid/gas separation section of the urea plant and the melamine off-gas to combined condensation in indirect heat exchange with the aqueous urea stream.

[0024] In a still further aspect, the invention presents the use of the foregoing methods for revamping a facility for the integrated production of urea and melamine.

Brief Description of the Drawings

[0025]

Fig. 1 is a schematic drawing of a conventional urea stripping plant.

Fig. 2 is a schematic drawing of a facility for the integrated production of urea and melamine according to an embodiment known in the art.

Fig. 3 is a graph wherein a typical energy consumption expressed in kg steam per produced ton of urea product is given as a function of the production capacity of the attached melamine plant at constant urea production capacity, for the embodiment of Fig. 2.

Fig. 4 is a schematic drawing of a facility for the integrated production of urea and melamine according to another embodiment known in the art.

Fig. 5 is a graph as in Fig. 3, for the embodiment of Fig. 4.

Fig. 6 is a schematic drawing of a reference facility for the integrated production of urea and melamine not according to an embodiment of the invention.

Fig. 7 is a graph as in Fig. 3, for the reference embodiment of Fig. 6.

Fig. 8 is a schematic drawing of a facility for the integrated production of urea and melamine according to an embodiment of the invention.

Fig. 9 is a graph as in Fig. 3, for the embodiment of Fig. 8.

Fig. 10 is a schematic drawing of a facility for the integrated production of urea and melamine according to another embodiment of the invention.

Fig. 11 is a graph as in Fig. 3, for the embodiment of Fig. 10.

Detailed Description of the Invention

[0026] In a general sense, the invention is based on the judicious insight how to put to use the thermal energy available from the off-gas stream of a melamine production zone (hereinafter also indicated as melamine off-gas) that is integrated with a urea production zone. This insight has resulted in combining the condensate of said off-gas, which has a relatively low water-content, and that of dissociated carbamate vapor (a gaseous stream comprising ammonia, carbon dioxide, and water) obtained from urea production, and having a higher water-content. The resulting combined condensate has a water-content above that of the off-gas of the melamine production zone. By thus diluting the melamine off-gas upon condensation, the resulting dilute condensate can be put to further use by being transported to elsewhere in the integrated production facility, particularly by being recirculated for use in urea synthesis.

[0027] In order to provide the combined condensate, the off-gas of the melamine production zone and the dissociated carbamate vapor of the urea production zone are directed to a condensation system suitable for generating and combining the condensates of both of the gas streams.

[0028] This refers to a system comprising a condenser for melamine off-gas, said condenser comprising a liquid outlet for condensed gas, and a condenser for the dissociated carbamate vapor comprising ammonia, carbon dioxide, and water, said condenser comprising a liquid outlet for condensed gas, wherein said liquid outlets are integrated into a single fluid transportation system. The condensation system, is single condenser, fed by both of the gas streams.

[0029] Essentially, the liquid output of the condensation system is a combined condensate of the off-gas of the melamine production zone and the dissociated carbamate vapor of the urea production zone. Preferably, the dilute condensate contains between 20 and 35% by weight of water.

[0030] Preferably, the condensation system is provided in the form of the shell side of a shell-and-tube heat exchanger. At any rate, the condensation system is in heat-exchanging communication with a device wherein the heat of condensation is put to use.

[0031] In the process according to the invention, the combined condensation of the dissociated carbamate vapor and the melamine off-gas is conducted in an indirect heat exchange with the aqueous urea stream.

[0032] Preferably, the indirect heat exchange is carried out in a shell and tube heat exchanger such that the dissociated carbamate vapor and the melamine off-gas are fed to the shell side of the heat exchanger, and the aqueous urea solution to the tube side thereof.

[0033] The heat exchange with the aqueous urea stream is employed so as to concentrate said stream. This results in a liquid stream, being a concentrated urea solution, and a gas stream, being evaporated water comprising ammonia and carbon dioxide.

[0034] As a result of the invention, the energy consumption of the integrated production facility is improved. The urea production zone is a urea stripping plant, and the increase in specific steam consumption in the urea plant is reduced, despite the additional steam needed as a result of the above-discussed lower stripping efficiency in a urea plant that processes off-gas from a melamine plant, and accordingly the amount of carbon dioxide fed directly to the stripper is reduced. Surprisingly the inventors further found that the specific energy consumption even decreases as the melamine production is increased.

[0035] It should be noted that, generally, the off-gas of melamine production will have a pressure in a range of, generally, 1.0 - 25 MPa, preferably 1.0 - 3.0 MPa, e.g. 1.5 - 2.5 MPa, and typically about 2 MPa. In the context of urea production, this would be considered medium pressure. Urea is typically synthesized at a high pressure, e.g. of 10 - 25 MPa and preferably 12 - 22 MPa. This implies that, if the dissociated ammonium dissociated carbamate vapor obtained from a high pressure stripper in a urea production zone, is to be joined with the off-gas from a melamine production zone into a combined condensate, the combined condensate will be formed only after condensation of the two gas streams.

[0036] The dissociated carbamate vapor is set to have a pressure sufficiently equal to the pressure of the melamine off-gas to allow combination in the gas phase. It is possible to subject the vapor and the off-gas to combined condensation.

This can be done if the dissociated carbamate vapor has about the right pressure, or is brought to the right pressure.

[0037] This can be realized, e.g., in a urea production zone provided with a medium-pressure stage. Such urea production zones are familiar to the skilled person. In the medium pressure stage, whole or part of the urea synthesis solution obtained from the high pressure synthesis section, is subjected to stripping, the output of the medium pressure stage being a stripped aqueous urea solution, and a medium-pressure dissociated carbamate vapor. Urea production zones including a medium pressure stage, typically comprising a medium pressure stripper and a medium pressure carbamate condenser, are known to the skilled person. See, e.g., Ullmann's Encyclopedia of Industrial Chemistry, Vol 37, (2012) p 657-693.

[0038] Medium pressure dissociated carbamate vapor can also be provided via flashing. In a preferred embodiment, the aforementioned processing of the urea synthesis stream so as to separate the aqueous urea stream from residual dissociated carbamate vapor comprising ammonia, carbon dioxide, and water, comprises subjecting the aqueous urea stream to adiabatic flashing, typically to a pressure in between 1.0 and 8.0 MPa and more specifically in between 1.5 and 5.0 MPa. This results in an expansion, causing a large part of ammonia, carbon dioxide and water to be separated, as a vapor, from the urea solution. This separated vapor, i.e. in effect a dissociated carbamate vapor, is of medium pressure, and can be directed to the same condensation system to which also the melamine off-gas is directed. There, the vapor and the off-gas can be combined in the gas-phase, and then subjected to combined condensation. The remaining urea solution is typically still subjected to regular recirculation processing, i.e. to further separate dissociated carbamate vapor from the urea solution. The latter dissociated carbamate vapor is preferably also directed to the aforementioned condensation system. An advantage of the step of adiabatic flashing, is that the heat from the urea synthesis can be recovered when the vapor resulting from the flashing is condensed and used in indirect heat exchange.

[0039] The invention finds useful application in an integrated production process for urea and melamine, and in a production facility therefor. It also finds useful application in a method for reducing the energy consumption of a urea production zone in a facility for the integrated production of urea and melamine. A particularly useful application is in increasing the capacity of a melamine plant integrated with a urea plant. In general, the invention provides a method for revamping a facility for the integrated production of urea and melamine.

[0040] The process for the integrated production of urea and melamine according to the invention comprises subjecting carbon dioxide and ammonia to urea forming conditions in a urea synthesis section so as to form a urea synthesis stream comprising urea, water and ammonium carbamate. This can be done using standard urea product technology available in the art.

[0041] The urea synthesis stream is subjected to processing, so as to separate urea from residual dissociated carbamate vapor comprising ammonia, carbon dioxide, and water. Methods to accomplish this, are well-known to the skilled person. Said dissociated carbamate vapor is generally condensed into a carbamate solution, which solution is recirculated to the urea synthesis section. This too, can be accomplished using standard urea production technology available to the skilled person.

[0042] The processing of the urea synthesis stream comprises subjecting said stream to stripping so as to form a stripped aqueous urea solution. Stripping can be done by providing heat (thermal stripping), or by using a stripping medium, generally a counter-current flow of a stripping gas. In urea production, typically ammonia or carbon dioxide are used as stripping media.

[0043] The stripped aqueous urea solution is subjected to a recirculation step wherein remaining ammonium carbamate is separated from urea, so as to form a urea solution and a dissociated carbamate vapor comprising ammonia, carbon dioxide, and water; said dissociated carbamate vapor is condensed into a carbamate solution, which is recirculated to the urea synthesis section.

[0044] In the invention, the condensation of the dissociated carbamate vapor is conducted in combination with the condensation of off-gas obtained from the melamine production section, and recirculated to the urea production section as part of the resulting combined condensate. The condensed fluid is used for heat exchange.

[0045] In the course of the integrated production of urea and melamine, urea formed in the urea production section is fed, as a starting material, to the melamine synthesis section where it is subjected to melamine-forming conditions. These conditions, and the associated equipment, for the synthesis of melamine are generally available to the skilled person.

[0046] Another part of the integration of urea and melamine production concerns the recirculation of the off-gas of the melamine synthesis section, to the urea synthesis section. It will be understood that, in the invention, this recirculation takes place, wholly or partially, after the above-described combined condensation. In other words, the melamine off-gas, after condensation, is recirculated to the urea synthesis section as part of the combined condensate of said off-gas and of dissociated carbamate vapor from urea production, as explained above.

[0047] In addition to the above-identified specific requirements for accomplishing the manner in which the melamine off-gas is used for condensation, the integration of the urea and melamine production can generally be accomplished in a manner known to the skilled person. To this extent, many set-ups for the integration of melamine and urea production plants are available in the art.

[0048] The integrated production of urea and melamine requires that a urea production zone and a melamine production zone are coupled as explained above. The production zones can be parts of a single, integrated plant. More typically, the production zones are separate plants, generally in a sufficiently close proximity of each other so as to make the integration economically and practically feasible.

[0049] The separate urea and melamine plants can be both built as new plants or, either or both of the plants can be pre-existing. If both plants pre-exist in sufficiently close proximity, it would be customary in the art to already have them integrated. However, it is also conceivable that no such integration has taken place, particularly in view of the drawbacks associated with the stripping efficiency of the urea plant outlined above. The invention obviates these drawbacks.

[0050] If the plants pre-exist in an integrated way, it is conceivable that the coupling to the urea plant effectively prevents the skilled person from increasing the capacity of the melamine plant, due to the problem of a lower stripping efficiency and/or higher steam consumption resulting from the increased feed of carbon dioxide and ammonia to the urea plant. The invention now solves this problem.

[0051] As to the urea production zone, a frequently used process for the preparation of urea according to a stripping process is the carbon dioxide stripping process as for example described in Ullmann's Encyclopedia of Industrial Chemistry, Vol. A27, 1996, pp 333-350. In this process, the synthesis section is followed by one or more recovery sections. The synthesis section comprises a reactor, a stripper, a condenser and a scrubber in which the operating pressure is in between 12 and 20 MPa and preferably in between 13 and 18 MPa. In the synthesis section the urea solution leaving the urea reactor is fed to a stripper in which a large amount of non-converted ammonia and carbon dioxide is separated from the aqueous urea solution. Such a stripper can be a shell and tube heat exchanger in which the urea solution is fed to the top part at the tube side and a carbon dioxide feed to the synthesis is added to the bottom part of the stripper. At the shell side, steam is added to heat the solution. The urea solution leaves the heat exchanger at the bottom part, while the vapor phase leaves the stripper at the top part. The vapor leaving said stripper contains ammonia, carbon dioxide and a small amount of water. Said vapor is condensed in a falling film type heat exchanger or a submerged type of condenser that can be a horizontal type or a vertical type. A horizontal type submerged heat exchanger is described in Ullmann's Encyclopedia of Industrial Chemistry, Vol. A27, 1996, pp 333-350. The heat released by the exothermic carbamate condensation reaction in said condenser is usually used to produce steam that is used in a downstream urea processing section for heating and concentrating the urea solution. Since a certain liquid residence time is created in a submerged type condenser, a part of the urea reaction takes already place in said condenser. The formed solution, containing condensed ammonia, carbon dioxide, water and urea together with the non-condensed ammonia, carbon dioxide and inert vapor is sent to the reactor. In the reactor the above mentioned reaction from carbamate to urea approaches the equilibrium. The ammonia to carbon dioxide molar ratio in the urea solution leaving the reactor is generally in between 2.5 and 4 mol/mol. It is also possible that the condenser and the reactor are combined in one piece of equipment. An example of this piece of equipment as described in Ullmann's Encyclopedia of Industrial Chemistry, Vol. A27, 1996, pp 333-350. The formed urea solution leaving the urea reactor is supplied to the stripper and the inert vapor containing non-condensed ammonia and carbon dioxide is sent to a scrubbing section operating at a similar pressure as the reactor. In that scrubbing section the ammonia and carbon dioxide is scrubbed from the inert vapor. The formed carbamate solution from the downstream recovery system is used as absorbent in that scrubbing section. In the invention, the formed carbamate in the combined condensate can be sent to the mentioned scrubber as absorbent and/or to the condensation zone in the synthesis section.

[0052] The invention is not limited to any particular urea production process carried out in a urea production zone comprising a reactor and a stripper. Other processes and plants include those that are based on technology such as the HEC process developed by Urea Casale, the ACES process developed by Toyo Engineering Corporation and the process developed by Snamprogetti.

[0053] As to the melamine production zone, this is preferably a melamine plant using a so-called high-pressure process. Melamine production processes are described for example in Ullmann's Encyclopedia of Industrial Chemistry, Vol. A16, fifth ed., pp. 174-179.

[0054] The invention also pertains to a facility for the integrated production of urea and melamine. Said facility comprises urea production zone and a melamine production zone, which can take the form of an integrated plant, or of two coupled separate plants, as substantially explained above. The urea production zone comprises a urea synthesis section and a carbamate recirculation section comprising a liquid/gas separation system; the melamine production zone comprises a melamine synthesis section and an off-gas separation section. In order for the production of urea and melamine to be integrated, the facility comprises a fluid transport line from the urea production zone to the melamine production zone, said line being suitable for feeding formed urea to the melamine synthesis section, and a gas flow line from the off-gas separation section of the melamine production zone to the urea synthesis section. In accordance with the invention, the facility further comprises a gas flow-line from the liquid/gas separation system to a condenser.

[0055] The aforementioned gas flow line from the melamine off-gas separation section, is directed to the gas inlet of a condenser for said melamine off-gas. The condenser comprises a liquid outlet for condensed gas. The gas flow-line from the liquid/gas separation section of the urea production zone is directed to the gas inlet of a condenser for vapor

comprising ammonia, carbon dioxide, and water, said condenser also comprising a liquid outlet for condensed gas. In accordance with the invention, the condenser for melamine off-gas and the condenser for said vapor are comprised in a condensation system, wherein said liquid outlets are integrated into a single fluid transportation system. The condensation system comprises a single condenser (wherein the gas inlets for both streams may be different, or they may be the same if the gas streams are combined in a location upstream of the condenser).

[0056] Said condensation system preferably comprises the shell-side of one or more shell-and-tube heat-exchangers.

[0057] The urea production zone is based on stripping technology, i.e. a urea stripping plant. The synthesis section of such a plant comprises a reactor and a stripper. In a further preferred embodiment, preferably combined with the aforementioned stripping technology, the condensation zone is in indirect heat exchange with the aqueous urea stream.

[0058] Preferably the indirect heat exchange is carried out in a shell and tube heat exchanger, the dissociated carbamate vapor and the melamine off-gas being fed to the shell side of the heat exchanger, and the aqueous urea solution to the tube side thereof.

[0059] It will be understood, that, in a preferred embodiment, the condensation system thus is part of a concentrator. From the aqueous urea stream fed into said concentrator, water will evaporate, resulting in a concentrated urea solution, and steam.

[0060] With a view of the preferred use, viz. to concentrate an aqueous urea solution, the condensation system preferably comprises one or more liquid feed lines that are in fluid communication with the urea synthesis section. Preferably, at least part of said fluid communication runs via the liquid/gas separation system. In a further preferred embodiment, the urea production zone further comprises a flashing system between the urea synthesis section and the carbamate recirculation section. The flashing system is in fluid communication with the urea synthesis section, so as to allow a urea synthesis stream to be fed to a liquid inlet of the flashing system. The flashing system has a gas outlet allowing dissociated carbamate vapor that is separated out of the urea synthesis stream as a result of flashing, to leave the flashing system. Preferably, said gas outlet is, or comprises, a gas-flow line to the same condensation system to which the melamine off-gas is directed. The flashing system has a liquid outlet that is in fluid communication with the carbamate recirculation section, so as to allow the urea solution remaining after flashing to be directed to the recirculation section, particularly to the liquid/gas separation system thereof.

[0061] Flashing systems are known to the skilled person.

[0062] The invention further provides a method for reducing the energy consumption of a urea production zone of a pre-existing facility for the integrated production of urea and melamine. The facility comprises a urea production zone and a melamine production zone; the urea production zone comprises a urea synthesis section and a carbamate recirculation section comprising a liquid/gas separation section; the melamine production zone comprises a melamine synthesis section and an off-gas separation section. According to the invention, the method comprises adding a concentrator to the urea production zone, said concentrator comprising a system for indirect heat-exchange with a gas-stream. The concentrator comprises an evaporation chamber for liquid to be heated, said evaporation chamber being in heat-exchanging communication with an indirect heating chamber for heating fluid. The method of the invention further comprises providing a transport line for liquid feed from the liquid/gas separation section of the urea plant to said evaporation chamber. Further, a gas flow-line is provided from the liquid/gas separation section of the urea plant to a condensation system, said condensation system comprising a liquid outlet in fluid communication with the indirect heating chamber. Finally, the invention comprises providing a gas flow-line from the off-gas separation section of the melamine production zone to the condensation system.

[0063] A particularly beneficial use of the invention, is in realizing a method of increasing the plant capacity of the melamine production zone of a pre-existing facility for the integrated production of urea and melamine. It will be understood that said facility comprises a urea production zone and a melamine production zone; the urea production zone comprising a urea synthesis section and a carbamate recirculation section comprising a liquid/gas separation section; the melamine production zone comprising a melamine synthesis section and an off-gas separation section. The method of the invention comprises expanding the melamine synthesis capacity of the melamine synthesis section. This can be done in known ways, e.g. by enlarging the size of the melamine reactor and downstream equipment, or by changing the operating conditions so as to allow a larger feed of urea to be processed per unit of time. The invention comprises adding a concentrator to the urea production zone, said concentrator comprising an evaporation chamber for liquid to be heated, said evaporation chamber being in heat-exchanging communication with an indirect heating chamber for heating fluid. The invention further comprises providing a transport line for liquid feed from the liquid/gas separation section of the urea plant to said evaporation chamber and providing a gas flow-line from the liquid/gas separation section of the urea plant to a condensation system. The condensation system comprises a liquid outlet in fluid communication with the indirect heating chamber. In accordance with the invention, a gas flow-line is further provided from the off-gas separation section of the melamine production zone to the condensation system.

[0064] As a result, the increased output of the melamine production zone, which goes with an increased output of off-gas comprising carbon dioxide and ammonia, can be employed to benefit from the heat of condensation available in said off-gas, as substantially described hereinbefore. The urea production zone comprises a urea stripping plant. It will

be understood that particular benefits in increasing the melamine production capacity of the invention, are attained in the invention wherein the urea production zone is based on stripping technology. Reference is made to the aforementioned problem of a lower stripping efficiency resulting from the reduced carbon dioxide or ammonia feed to the stripper that is necessitated by the increased feed of reactants from the melamine off-gas. The invention seeks to obviate this problem, by providing an additional source of heat, viz. from the above-described combined condensation of the melamine off-gas and dissociated carbamate vapor.

[0065] In general, either or both of the foregoing methods, i.e. for reducing the energy consumption in a urea production zone and increasing the melamine production capacity of a melamine production zone, can be put to use in revamping a facility for the integrated production of urea and melamine.

[0066] The invention will hereinafter be further illustrated with reference to the following non-limiting examples. All the examples relate to a urea plant with a capacity of 1900 mt/day.

Example 1 (reference)

[0067] Fig. 1 illustrates a urea plant according a typical CO₂ stripping technology as described in the Ullmann's Encyclopaedia of Industrial Chemistry, Vol. A27, 1996, pp 333-350. In this process the carbon dioxide used as a feedstock enters the high-pressure stripper HPSTR via line b. In the stripper HPSTR the reactor effluent from the high-pressure reactor HPREA is contacting counter currently with carbon dioxide, causing the ammonia partial pressure to decrease and the carbamate in that solution to decompose. The heat, required for this purpose to complete the carbamate decomposition to the desired efficiency is supplied by passing saturated high pressure steam around the tubes of the high pressure stripper HPSTR. The vapor leaving the stripper HPSTR comprising ammonia, carbon dioxide and a small portion of water is sent via line c to the high-pressure carbamate condenser HPCC. This high-pressure carbamate condenser HPCC can be a falling film type condenser, a kettle type condenser or a submerged type condenser. In the high-pressure carbamate condenser HPCC the released condensation heat is used to produce saturated steam at a pressure in between 0.2 and 0.6 MPa that is used for i.e. heating in the downstream processing of the urea plant. Ammonia as a feedstock is supplied to the high-pressure carbamate condenser HPCC via line a prior to the high-pressure ejector HPEJ where said ammonia is used as driving force to convey the formed carbamate in the high-pressure scrubber HPSCR via line g to said high-pressure carbamate condenser HPCC via line h.

[0068] The formed carbamate in the high-pressure carbamate condenser HPCC comprising ammonia, carbon dioxide, water and optionally urea together with the non-condensed vapor leaving said high-pressure carbamate condenser comprising ammonia, carbon dioxide, water, nitrogen, oxygen and low concentrations of other inert components arrive in the high-pressure reactor HPREA under gravity flow via line d. In the high-pressure reactor the remaining conversion of ammonia and carbon dioxide into urea takes place to approach equilibrium. The formed urea solution leaving the high-pressure reactor HPREA comprising urea, ammonia, carbon dioxide, water and small amounts of other components flow via gravity flow to said stripper HPSTR. The inert vapor leaving the high-pressure reactor HPREA via line e comprising non-condensed ammonia, carbon dioxide, nitrogen, oxygen and small amounts of other inert components are supplied to the high-pressure scrubber HPSCR. In the high-pressure scrubber HPSCR the bulk of non-condensed ammonia and carbon dioxide is separated from the inert vapor comprising mainly the components nitrogen and oxygen by contacting the vapor leaving the high-pressure reactor HPREA with a carbamate solution via line ac formed in the downstream processing of the urea plant. Optionally the carbamate solution leaving the high-pressure reactor HPREA is subjected to a condenser at first where after the leaving inert vapor is brought in contact with said carbamate solution from the downstream processing. The formed carbamate in this scrubber HPSCR is sent via line g to the high-pressure ejector HPEJ. The inert vapor leaving the high-pressure scrubber HPSCR via line f is vented into the atmosphere or is further treated in i.e. an absorber before it is released into the atmosphere.

[0069] The urea solution leaving the high-pressure stripper HPSTR is sent to a recirculation section LPREC via line aa. The recirculation section LPREC is operated at a pressure below the pressure in the synthesis section. In this recirculation section LPREC the separation between the non-converted ammonia and carbon dioxide and urea water solution takes place. The separated ammonia and carbon dioxide is condensed to form a carbamate solution that is returned via line ac to the high-pressure scrubber HPSCR in the synthesis section. The urea solution comprising urea, water and small amounts of ammonia and carbon dioxide is collected in a storage tank UW where after this solution via line ad is concentrated by evaporation EVAP to its desired concentration needed to finish the product via line ae to its final solid product. The energy consumption expressed in kg steam per ton of produced urea varies typically in between 870 and 950 kg per ton depend from the steam quality and type of finishing that is used to produce the final product. In this example the energy consumption is 920 kg/ton.

Example 2 (reference)

[0070] Fig. 2 illustrates the process as described in the prior art and disclosed in WO 98/08808 A1.

[0071] This process comprises the urea plant as described for figure 1 (capacity 1900 mt/day) and the vapor from the melamine plant comprising ammonia, carbon dioxide and optionally water and inert VAPMEL is added to the high-pressure carbamate condenser HPCC in the synthesis section.

[0072] Fig. 3 is a graph wherein a typical energy consumption expressed in kg steam per produced ton of urea product is given as a function of the attached plant capacity of the melamine plant at constant urea production capacity.

[0073] As expected, the energy consumption of the urea plant increases if the plant capacity of the connected melamine plant increases caused by the increased vapor from said melamine plant to be processed in said urea plant.

Example 3 (reference)

[0074] Fig. 4 illustrates an example of an embodiment according to the prior art as disclosed in US 7,893,298 B2. This process comprises the urea plant as described for figure 1 (capacity 1900 mt/day) and the vapor from the melamine plant comprising ammonia, carbon dioxide and optionally water and inert VAPMEL is condensed in condenser CARBCOND where after the formed carbamate solution is added to the synthesis section of said urea plant. In this example said formed carbamate is added via line af to the high-pressure scrubber HPSCR of the urea synthesis however it is also possible to add this carbamate solution or part of the solution elsewhere in the urea synthesis section such as the high-pressure carbamate condenser HPCC of the urea plant. In the condenser CARBCOND typically the formed carbamate in the downstream processing of the urea plant is added as a solvent via ac and typically the water concentration in said added carbamate solution from the recirculation section LPREC is higher than the water concentration in the formed carbamate solution leaving the condenser CARBCOND. Typically the pressure in the condenser CARBCOND is higher than the pressure in the recirculation section LPREC from which the carbamate is added and lower than the pressure from the melamine plant section where the vapor from the melamine plant VAPMEL is released. In the condenser CARBCOND, the released heat of condensation is dissipated in cooling water or is used to generate steam that might be used in the downstream processing of the urea plant.

[0075] Fig. 5 is a graph wherein a typical energy consumption expressed in kg steam per produced ton of urea product is given as a function of the attached plant capacity of the melamine plant at constant urea production capacity. The energy consumption of an integrated urea plant and melamine plant at constant urea production capacity shows that there a slight increase related to the original urea plant without melamine integration.

Example 4 (reference)

[0076] In Figure 6 a reference plant and a reference method not according to the invention is elucidated. This process comprises the urea plant as described for figure 1 (1900 mt/day). The urea solution leaving the high pressure stripper HPSTR in the synthesis section of the urea plant via line aa is added to the low pressure recirculation. The vapor from the melamine plant comprising ammonia, carbon dioxide and but not necessarily water, is added to a concentrator PREEVAP in which the urea solution leaving the recirculation LPREC via line bd is concentrated where after the concentrated solution is collected in the storage UW via line bb.

[0077] The concentrator PREEVAP is preferably a shell and tube heat exchanger in which the vapors leaving the melamine plant are preferably added to the shell side of this concentrator and the urea solution leaving the recirculation section is preferably added to the tube side of said concentrator. Furthermore the formed carbamate solution produced in the recirculation section is added via line ac to the shell side of the concentrator PREEVAP as well. The formed carbamate in said concentrator PREEVAP is conveyed by preferably a pump via line af to the synthesis section. In this reference example this carbamate solution is added to the scrubber HPSCR in the synthesis section but elsewhere in the synthesis section such as the high-pressure carbamate condenser HPCC is possible as well. The non-condensed vapor leaving the shell side of this concentrator is usually sent to an absorber placed in the urea plant. Typically the water concentration in said added carbamate solution from the recirculation section LPREC is higher than the water concentration in the formed carbamate solution leaving the concentrator PREEVAP. Typically the pressure in the shell side of the concentrator PREEVAP condenser is equal or below the operating pressure from the vapors added from the melamine plant VAPMEL but higher than the pressure in the low pressure recirculation section LPREC.

[0078] Fig. 7 is a graph wherein a typical energy consumption expressed in kg steam per produced ton of urea product is given as a function of the attached plant capacity of the melamine plant at constant urea production capacity.

[0079] This graph shows that the energy consumption of an integrated urea plant and melamine plant at constant urea production capacity is about 20 to 50 kg steam per ton of produced urea product lower as compared to a typical urea plant without a melamine integration as shown in figure 1. Furthermore the steam consumption of the urea plant at constant production rate decreases at increasing melamine plant capacity.

Example 5

[0080] In Figure 8 an embodiment of the invention is elucidated. This process comprises the urea plant as described for figure 1 (capacity 1900 mt/day). The urea solution leaving the high pressure stripper HPSTR in the synthesis section of the urea plant via line aa is adiabatic expanded FLASH to a pressure in between 1.0 and 8.0 MPa and more specifically in between 1.5 and 6.0 MPa. By the expansion a large part of ammonia, carbon dioxide and water is separated from the urea solution that comprises mainly the components urea and water next to some residual ammonia and carbon dioxide that is dissolved in the urea solution. Said urea solution is discharged via line bc to the recirculation section LPREC of the urea plant. The flashed vapor from the adiabatic flash step FLASH, comprising ammonia, carbon dioxide and water is discharged via line ba to a concentrator PREEVAP in which the urea solution leaving the recirculation LPREC via line bd is concentrated where after the concentrated solution is collected in the storage UW via line bb. The vapor leaving the melamine plant comprising ammonia, carbon dioxide and optionally water is added to the concentrator PREEVAP as well. Again the concentrator PREEVAP is preferably a shell and tube heat exchanger in which the vapors leaving the adiabatic expansion FLASH and the vapors leaving the melamine plant are preferably in combination added to the shell side of this concentrator and the urea solution leaving the recirculation section is preferably added to the tube side of said concentrator. Furthermore the formed carbamate solution produced in the recirculation section LPREC is added via line ac to the shell side of the concentrator PREEVAP as well. The formed carbamate in said concentrator PREEVAP is conveyed by preferably a pump via line af to the synthesis section. In this example this carbamate solution is added to the scrubber HPSCR in the synthesis section but elsewhere in the synthesis section such as the high-pressure carbamate condenser HPCC is possible as well. The non-condensed vapor leaving the shell side of this concentrator is usually sent to an absorber placed in the urea plant. Typically the water concentration in said added carbamate solution from the recirculation section LPREC is higher than the water concentration in the formed carbamate solution leaving the concentrator PREEVAP. Typically the pressure in the shell side of the concentrator PREEVAP condenser is equal or below the operating pressure where the adiabatic expansion FLASH takes place although said pressure is higher than the pressure in the recirculation section LPREC from which the carbamate is added.

[0081] Fig. 9 is a graph wherein a typical energy consumption expressed in kg steam per produced ton of urea product is given as a function of the attached plant capacity of the melamine plant at constant urea production capacity.

[0082] This graph shows that the energy consumption of an integrated urea plant and melamine plant at constant urea production capacity is about 50 to 150 kg steam per ton of produced urea product lower as compared to a typical urea plant without a melamine integration as shown in figure 1. Furthermore the steam consumption of the urea plant at constant rate decreases at increasing plant capacity of the melamine plant.

Example 6

[0083] This example concerns an embodiment of the invention as shown in figure 10. In several aspects, this embodiment is similar to the embodiment as described in Example 5. In the present Example, however, the concentrator PREEVAP is located downstream the storage UW and upstream the evaporation section EVAP where the urea solution is concentrated to its desired concentration necessary to finish the formed urea melt to its final product. The off-gas leaving the high-pressure reactor in the synthesis section is sent via line e to the flashed vapor from the adiabatic flash FLASH. This embodiment is preferred above the embodiment as shown in figure 5 since in this embodiment fuming of ammonia in the storage UW is avoided and by larger capacities of the melamine plant for instance makes this embodiment possible to concentrate the urea solution in the concentrator PREEVAP deeper without the chance of ammonia fuming in the stored urea solution UW as compared to the embodiment of Example 5, as shown in figure 8.

[0084] Fig. 11 is a graph wherein a typical energy consumption expressed in kg steam per produced ton of urea product is given as a function of the attached plant capacity of the melamine plant at constant urea production capacity.

[0085] This graph shows that the energy consumption of an integrated urea plant and melamine plant at constant urea production capacity is about 50 to 150 kg steam per ton of produced urea product lower as compared to a typical urea plant without a melamine integration as shown in figure 1. Furthermore the steam consumption of the urea plant at constant rate decreases slightly at increasing plant capacity of the melamine plant.

Claims

1. A process for the integrated production of urea and melamine, the process comprising subjecting carbon dioxide and ammonia to urea forming conditions in a urea production zone comprising a reactor and a stripper, so as to form a urea synthesis stream comprising urea, water and ammonium carbamate; subjecting the urea synthesis stream to processing so as to obtain an aqueous urea stream and a vapor comprising ammonia, carbon dioxide, and water, wherein said processing comprises stripping in said stripper; feeding urea to a melamine production

zone; subjecting the urea fed to the melamine production zone to melamine forming conditions so as to form melamine and melamine off-gas comprising carbon dioxide and ammonia; feeding the off-gas to the urea production zone; subjecting the vapor and the melamine off-gas to combined condensation in indirect heat exchange with the aqueous urea stream; forming a combined stream of the condensate of the vapor and the condensate of the off-gas, so as to provide a dilute melamine off-gas condensate, and using said dilute melamine off-gas condensate as a fluid in said indirect heat-exchange.

2. A process according to claim 1, wherein the indirect heat exchange takes place so as to concentrate the aqueous urea stream by heat-induced evaporation.
3. A process according to claim 2, wherein the indirect heat exchange is carried out in a shell and tube heat exchanger, the vapor and the melamine off-gas being fed to the shell side of the heat exchanger, and the aqueous urea solution to the tube side thereof.
4. A process according to any one of the preceding claims, wherein the vapor is set to have a pressure sufficiently equal to the pressure of the melamine off-gas to allow combination in the gas phase.
5. A process according to any one of the preceding claims, wherein the dilute melamine off-gas condensate is recirculated to the urea synthesis section.
6. A process according to any one of the preceding claims, wherein the urea synthesis section comprises said reactor and said stripper, and furthermore a condenser and a scrubber, wherein the operating pressure in the urea synthesis section is between 12 and 20 MPa.
7. A process according to any one of the preceding claims, wherein the dilute condensate contains of from 20 wt.% to 35 wt.% of water.
8. A process according to any one of the preceding claims, wherein the processing so as to obtain an aqueous urea stream and a vapor comprising ammonia, carbon dioxide, and water further comprises subjecting the urea synthesis stream to adiabatic flashing.
9. A facility for the integrated production of urea and melamine, said facility comprising a urea production zone and a melamine production zone; the urea production zone comprising a urea synthesis section comprising a reactor and a stripper, and a carbamate recirculation section comprising an inlet for stripped aqueous urea solution and a liquid/gas separation section; the melamine production zone comprising a melamine synthesis section and an off-gas separation section; said facility comprising a fluid transport line from the urea production zone to the melamine production zone, said line being suitable for feeding formed urea to the melamine synthesis section, a gas flow line from the off-gas separation section of the melamine production zone to the urea synthesis section, said gas flow line being in communication with a gas inlet of a condenser for melamine off-gas, said condenser comprising a liquid outlet for condensed gas, and a gas flow-line for vapor from the liquid/gas separation section in fluid communication with said condenser, wherein said condenser for melamine off-gas and for said vapor is comprised in a condensation system.
10. A facility according to claim 9, wherein the condensation system comprises the shell-side of one or more shell-and-tube heat-exchangers.
11. A facility according to claim 9 or 10, wherein the liquid outlet line of the condensation system is in fluid communication with the urea synthesis section.
12. A facility according to any one of the claims 9 to 11, comprising a flashing section having a liquid inlet in fluid communication with a liquid outlet of the urea synthesis section, a liquid outlet in fluid communication with a liquid inlet of the carbamate recirculation section, and a gas-flow line to the condensation system.
13. A method for reducing the energy consumption of a urea production zone of a pre-existing facility for the integrated production of urea and melamine, said facility comprising a urea production zone and a melamine production zone; the urea production zone comprising a urea synthesis section comprising a reactor and a stripper, and a carbamate recirculation section comprising an inlet for stripped aqueous urea solution and a liquid/gas separation section;

the melamine production zone comprising a melamine synthesis section and an off-gas separation section,
the method comprising

- adding a concentrator to the urea production zone,

said concentrator comprising an evaporation chamber for liquid to be heated and evaporated,
said evaporation chamber comprising a gas outlet for evaporated liquid and being in heat-exchanging communication with a chamber for indirect heat exchange; providing a transport line for liquid feed from the liquid/gas separation section of the urea plant to said evaporation chamber;

- providing a gas flow-line from the liquid/gas separation section of the urea plant to a condensation system, said condensation system comprising a liquid outlet in fluid communication with the chamber for indirect heat exchange;
- and providing a gas flow-line from the off-gas separation section of the melamine production zone to the condensation system, wherein said condensation system is configured for subjecting the vapor from the liquid/gas separation section of the urea plant and the melamine off-gas to combined condensation in indirect heat exchange with the aqueous urea stream.

- 14.** A method of increasing the plant capacity of the melamine production zone of a pre-existing facility for the integrated production of urea and melamine,
said facility comprising a urea production zone and a melamine production zone;
the urea production zone comprising a urea synthesis section comprising a reactor and a stripper, and a carbamate recirculation section comprising an inlet for stripped aqueous urea solution and a liquid/gas separation section;
the melamine production zone comprising a melamine synthesis section and an off-gas separation section,
the method comprising

- expanding the melamine synthesis capacity of the melamine synthesis section;
- adding a concentrator to the urea production zone,

said concentrator comprising an evaporation chamber for liquid to be heated and evaporated,
said evaporation chamber comprising a gas outlet for evaporated liquid and being in heat-exchanging communication with a chamber for indirect heat exchange;

- providing a transport line for liquid feed from the liquid/gas separation section of the urea plant to said evaporation chamber;

providing a gas flow-line from the liquid/gas separation section of the urea plant to a condensation system, said condensation system comprising a liquid outlet in fluid communication with the chamber for indirect heat exchange;

- and providing a gas flow-line from the off-gas separation section of the melamine production zone to the condensation system,

wherein said condensation system is configured for subjecting the vapor from the liquid/gas separation section of the urea plant and the melamine off-gas to combined condensation in indirect heat exchange with the aqueous urea stream.

- 15.** The use of a method according to either or both of claims 13 and 14 for revamping a facility for the integrated production of urea and melamine.

Patentansprüche

- 1.** Verfahren zur integrierten Herstellung von Harnstoff und Melamin, wobei das Verfahren Aussetzen von Kohlendioxid und Ammoniak Harnstoffbildungsbedingungen in einer Harnstoffproduktionszone umfasst, umfassend einen Reaktor und einen Stripper, um so einen Harnstoffsynthesestrom zu bilden, umfassend Harnstoff, Wasser und Ammoniumcarbamat; Aussetzen des Harnstoffsynthesestroms einer Verarbeitung, um so einen wässrigen Harnstoffstrom und einen Dampf zu erhalten, umfassend Ammoniak, Kohlendioxid und Wasser, wobei die Verarbeitung Strippen

in dem Stripper umfasst; Zufuhr von Harnstoff zu einer Melaminproduktionszone; Aussetzen des Harnstoffs, der der Melaminproduktionszone zugeführt wird, melaminbildenden Bedingungen, um so Melamin und Melaminabgas zu bilden, umfassend Kohlendioxid und Ammoniak; Zufuhr des Abgases zu einer Harnstoffproduktionszone; Aussetzen des Dampfers und Melaminabgases kombinierter Kondensation in indirektem Wärmeaustausch mit dem wässrigen Harnstoffstrom; Bilden eines kombinierten Stroms aus dem Kondensat des Dampfes und des Kondensats des Abgases, um so ein verdünntes Melaminabgaskondensat bereitzustellen, und Verwenden des verdünnten Melaminabgaskondensats als eine Flüssigkeit in dem indirekten Wärmeaustausch.

2. Verfahren nach Anspruch 1, wobei der indirekte Wärmeaustausch stattfindet, um so den wässrigen Harnstoffstrom durch wärmeinduzierte Verdampfung zu konzentrieren.

3. Verfahren nach Anspruch 2, wobei der indirekte Wärmeaustausch in einem Rohrbündelwärmeübertrager durchgeführt wird, wobei der Dampf und das Melaminabgas, der Mantelseite des Wärmetauschers, und die wässrige Harnstofflösung der Rohrseite davon zugeführt werden.

4. Verfahren nach einem der vorhergehenden Ansprüche, wobei der Dampf festgelegt wird, einen Druck ausreichend gleich dem Druck des Melaminabgases zu sein, um Kombination in der Gasphase zu ermöglichen.

5. Verfahren nach einem der vorhergehenden Ansprüche, wobei das verdünnte Melaminabgaskondensat in den Harnstoffsyntheseabschnitt zurückgeführt wird.

6. Verfahren nach einem der vorhergehenden Ansprüche, wobei der Harnstoffsyntheseabschnitt den Reaktor und den Stripper, und zudem einen Kondensator und einen Wäscher umfasst, wobei der Betriebsdruck im Harnstoffsyntheseabschnitt zwischen 12 und 20 MPa liegt.

7. Verfahren nach einem der vorhergehenden Ansprüche, wobei das verdünnte Kondensat von von 20 Gew.-% bis 35 Gew.-% Wasser enthält.

8. Verfahren nach einem der vorhergehenden Ansprüche, wobei das Verarbeiten zum Erhalt eines wässrigen Harnstoffstroms und eines Dampfes, umfassend Ammoniak, Kohlendioxid und Wasser, weiter Aussetzen des Harnstoffsynthesestroms adiabatischer Verdunstung umfasst.

9. Anlage zur integrierten Produktion von Harnstoff und Melamin, die Anlage umfassend eine Harnstoffproduktionszone und eine Melaminproduktionszone; die Harnstoffproduktionszone umfassend einen Harnstoffsyntheseabschnitt, umfassend einen Reaktor und einen Stripper, und einen Carbamat-Rezirkulationsabschnitt, umfassend einen Einlass für gestrippte wässrige Harnstofflösung und einen Flüssigkeits-/Gastrennabschnitt; die Melaminproduktionszone, umfassend einen Melaminsyntheseabschnitt und einen Abgastrennabschnitt; die Anlage umfassend eine Flüssigkeitstransportleitung von der Harnstoffproduktionszone zur Melaminproduktionszone, wobei die Leitung geeignet ist, gebildeten Harnstoff dem Melaminsyntheseabschnitt zuzuführen, eine Gasströmungsleitung von dem Abgastrennabschnitt der Melaminproduktionszone zu dem Harnstoffsyntheseabschnitt, wobei die Gasströmungsleitung mit einem Gaseinlass eines Kondensators für Melaminabgas in Kommunikation ist, der Kondensator umfassend einen Flüssigkeitsauslass für kondensiertes Gas und eine Gasströmungsleitung für Dampf aus dem Flüssigkeits-/Gastrennabschnitt in Fluidkommunikation mit dem Kondensator, wobei der Kondensator für Melaminabgas und für den Dampf in einem Kondensationssystem umfasst ist.

10. Anlage nach Anspruch 9, wobei das Kondensationssystem die Mantelseite eines oder mehrerer Rohrbündelwärmetauscher umfasst.

11. Anlage nach Anspruch 9 oder 10, wobei die Flüssigkeitsauslassleitung des Kondensationssystems mit dem Harnstoffsyntheseabschnitt in Fluidkommunikation steht.

12. Anlage nach einem der Ansprüche 9 bis 11, umfassend einen Verdunstungsabschnitt mit einem Flüssigkeitseinlass in Fluidkommunikation mit einem Flüssigkeitsauslass des Harnstoffsyntheseabschnitts, einem Flüssigkeitsauslass in Fluidkommunikation mit einem Flüssigkeitseinlass des Carbamat-Rezirkulationsabschnitts. und eine Gasströmungsleitung zu dem Kondensationssystem.

13. Verfahren zur Verringerung des Energieverbrauchs einer Harnstoffproduktionszone einer bereits bestehenden Anlage zur integrierten Produktion von Harnstoff und Melamin, die Anlage umfassend eine Harnstoffproduktionszone

und eine Melaminproduktionszone; die Harnstoffproduktionszone umfassend einen Harnstoffsyntheseabschnitt, umfassend einen Reaktor und einen Stripper, und einen Carbamat-Rezirkulationsabschnitt, umfassend einen Einlass für gestrippte wässrige Harnstofflösung und einen Flüssigkeits-/Gastrennabschnitt; die Melaminproduktionszone umfassend einen Melaminsyntheseabschnitt und einen Abgastrennabschnitt, das Verfahren umfassend

- Hinzufügen eines Konzentrators zu der Harnstoffproduktionszone, der Konzentrador umfassend eine Verdampfungskammer für zu erwärmende und zu verdampfende Flüssigkeit, die Verdampfungskammer umfassend einen Gasauslass für verdampfte Flüssigkeit und mit einer Kammer zum indirekten Wärmeaustausch in Wärmeaustauschkommunikation stehend; Bereitstellen einer Transportleitung zur Flüssigkeitszufuhr von dem Flüssigkeits-/Gastrennabschnitt der Harnstoffanlage zur Verdampfungskammer;
- Bereitstellen einer Gasströmungsleitung von dem Flüssigkeits-/Gastrennabschnitt der Harnstoffanlage zu einem Kondensationssystem, das Kondensationssystem umfassend einen Flüssigkeitsauslass, in Fluidkommunikation mit der Kammer für den indirekten Wärmeaustausch;
- und Bereitstellen einer Gasströmungsleitung von dem Abgastrennabschnitt der Melaminproduktionszone zu dem Kondensationssystem, wobei das Kondensationssystem konfiguriert ist, um den Dampf aus dem Flüssigkeits-/Gastrennabschnitt der Harnstoffanlage und Melaminabgas kombinierter Kondensation im indirekten Wärmeaustausch mit dem wässrigen Harnstoffstrom auszusetzen.

14. Verfahren zur Erhöhung der Anlagenkapazität der Melaminproduktionszone einer bereits bestehenden Anlage zur integrierten Produktion von Harnstoff und Melamin, die Anlage umfassend eine Harnstoffproduktionszone und eine Melaminproduktionszone; die Harnstoffproduktionszone umfassend einen Harnstoffsyntheseabschnitt, umfassend einen Reaktor und einen Stripper, und einen Carbamat-Rezirkulationsabschnitt, umfassend einen Einlass für gestrippte wässrige Harnstofflösung und einen Flüssigkeits-/Gastrennabschnitt; die Melaminproduktionszone umfassend einen Melaminsyntheseabschnitt und einen Abgastrennabschnitt, das Verfahren umfassend

- Erweiterung der Melaminsynthesekapazität des Melaminsyntheseabschnitts;
- Hinzufügen eines Konzentrators zu der Harnstoffproduktionszone, der Konzentrador umfassend eine Verdampfungskammer für zu erwärmende und zu verdampfende Flüssigkeit, die Verdampfungskammer umfassend einen Gasauslass für verdampfte Flüssigkeit und mit einer Kammer zum indirekten Wärmeaustausch in Wärmeaustauschkommunikation;
- Bereitstellen einer Transportleitung für die Flüssigkeitszufuhr von dem Flüssigkeits-/Gastrennabschnitt der Harnstoffanlage zur Verdampfungskammer;
- Bereitstellen einer Gasströmungsleitung von dem Flüssigkeits-/Gastrennabschnitt der Harnstoffanlage zu einem Kondensationssystem, wobei das Kondensationssystem einen Flüssigkeitsauslass umfasst, der in Fluidkommunikation mit der Kammer für den indirekten Wärmeaustausch steht;
- und Bereitstellen einer Gasströmungsleitung von dem Abgastrennabschnitt der Melaminproduktionszone zu dem Kondensationssystem, wobei das Kondensationssystem konfiguriert ist, um den Dampf aus dem Flüssigkeits-/Gastrennabschnitt der Harnstoffanlage und Melaminabgas kombinierter Kondensation im indirekten Wärmeaustausch mit dem wässrigen Harnstoffstrom auszusetzen.

15. Verwendung eines Verfahrens nach einem oder beiden der Ansprüche 13 und 14 zur Modernisierung einer Anlage zur integrierten Produktion von Harnstoff und Melamin.

Revendications

1. Procédé pour la production intégrée d'urée et de mélamine, le procédé consistant à soumettre du dioxyde de carbone et de l'ammoniaque à des conditions de formation d'urée dans une zone de production d'urée comprenant un réacteur et un épurateur, pour former un courant de synthèse d'urée comprenant de l'urée, de l'eau et du carbamate d'ammonium ; à soumettre le courant de synthèse d'urée à un traitement pour obtenir un courant d'urée aqueuse et une vapeur comprenant de l'ammoniaque, du dioxyde de carbone, et de l'eau, dans lequel ledit traitement comprend l'épuration dans ledit épurateur ; l'introduction d'urée dans une zone de production de mélamine ; la soumission de l'urée introduite dans la zone de production de mélamine à des conditions de formation de mélamine pour former de la mélamine et un dégagement gazeux de mélamine comprenant du dioxyde de carbone et de l'ammoniaque ; l'introduction du dégagement gazeux dans la zone de production d'urée ; la soumission de la vapeur et du dégagement gazeux de mélamine à une condensation combinée dans un échangeur de chaleur indirect avec le courant d'urée aqueuse ; la formation d'un courant combiné du condensat de la vapeur et du condensat du dégagement

gazeux, pour fournir un condensat de dégagement gazeux de mélamine dilué, et l'utilisation dudit condensat de dégagement gazeux de mélamine dilué comme un fluide dans ledit échangeur de chaleur indirect.

2. Procédé selon la revendication 1, dans lequel l'échange de chaleur indirect a lieu pour concentrer le courant d'urée aqueuse par une évaporation induite par de la chaleur.
3. Procédé selon la revendication 2, dans lequel l'échange de chaleur indirect est réalisé dans un échangeur de chaleur calandre et tube, la vapeur et le dégagement gazeux de mélamine étant introduits sur le côté calandre de l'échangeur de chaleur, et la solution d'urée aqueuse sur le côté tube de celui-ci.
4. Procédé selon l'une quelconque des revendications précédentes, dans lequel la vapeur est ajustée pour présenter une pression suffisamment égale à la pression du dégagement gazeux de mélamine pour permettre une combinaison dans la phase gazeuse.
5. Procédé selon l'une quelconque des revendications précédentes, dans lequel le condensat de dégagement gazeux de mélamine dilué est remis en circulation dans la section de synthèse d'urée.
6. Procédé selon l'une quelconque des revendications précédentes, dans lequel la section de synthèse d'urée comprend ledit réacteur et ledit épurateur, et de plus un condenseur et un purificateur, dans lequel la pression de fonctionnement dans la section de synthèse d'urée est de 12 à 20 MPa.
7. Procédé selon l'une quelconque des revendications précédentes, dans lequel le condensat dilué contient de 20 % en masse à 35 % en masse d'eau.
8. Procédé selon l'une quelconque des revendications précédentes, dans lequel le traitement pour obtenir un courant d'urée aqueuse et une vapeur comprenant de l'ammoniaque, du dioxyde de carbone, et de l'eau consiste de plus à soumettre le courant de synthèse d'urée à une vaporisation éclair adiabatique.
9. Installation pour la production intégrée d'urée et de mélamine, ladite installation comprenant une zone de production d'urée et une zone de production de mélamine ; la zone de production d'urée comprenant une section de synthèse d'urée comprenant un réacteur et un épurateur, et une section de recirculation de carbamate comprenant une entrée pour une solution d'urée aqueuse épurée et une section de séparation liquide/gaz ; la zone de production de mélamine comprenant une section de synthèse de mélamine et une section de séparation de dégagement gazeux ; ladite installation comprenant une ligne de transport de fluide à partir de la zone de production d'urée vers la zone de production de mélamine, ladite ligne étant appropriée pour introduire de l'urée formée dans la section de synthèse de mélamine, une ligne d'écoulement de gaz à partir de la section de séparation de dégagement gazeux de la zone de production de mélamine vers la section de synthèse d'urée, ladite ligne d'écoulement de gaz étant en communication avec une entrée de gaz d'un condenseur pour dégagement gazeux de mélamine, ledit condenseur comprenant une sortie de liquide pour du gaz condensé, et une ligne d'écoulement de gaz pour de la vapeur à partir de la section de séparation liquide/gaz en communication fluide avec ledit condenseur, dans laquelle ledit condenseur pour dégagement gazeux de mélamine et pour ladite vapeur est compris dans un système de condensation.
10. Installation selon la revendication 9, dans laquelle le système de condensation comprend le côté calandre d'un ou plusieurs échangeurs de chaleur calandre et tube.
11. Installation selon la revendication 9 ou 10, dans laquelle la ligne de sortie de liquide du système de condensation est en communication fluide avec la section de synthèse d'urée.
12. Installation selon l'une quelconque des revendications 9 à 11, comprenant une section de vaporisation éclair présentant une entrée de liquide en communication fluide avec une sortie de liquide de la section de synthèse d'urée, une sortie de liquide en communication fluide avec une entrée de liquide de la section de recirculation de carbamate, et une ligne d'écoulement de gaz vers le système de condensation.
13. Procédé de réduction de la consommation d'énergie d'une zone de production d'urée d'une installation préexistante pour la production intégrée d'urée et de mélamine, ladite installation comprenant une zone de production d'urée et une zone de production de mélamine ; la zone de production d'urée comprenant une section de synthèse d'urée comprenant un réacteur et un épurateur, et une section de recirculation de carbamate comprenant une entrée pour une solution d'urée aqueuse épurée et une section de séparation liquide/gaz ;

la zone de production de mélamine comprenant une section de synthèse de mélamine et une section de séparation de dégagement gazeux,
le procédé comprenant

- 5 - l'addition d'un concentrateur à la zone de production d'urée, ledit concentrateur comprenant une chambre d'évaporation pour du liquide à chauffer et à faire évaporer,
ladite chambre d'évaporation comprenant une sortie de gaz pour du liquide évaporé et étant en communication d'échange de chaleur avec une chambre pour échange de chaleur indirect ;
- 10 la fourniture d'une ligne de transport pour l'introduction de liquide à partir de la section de séparation liquide/gaz de l'usine d'urée vers ladite chambre d'évaporation ;
- la fourniture d'une ligne d'écoulement de gaz à partir de la section de séparation liquide/gaz de l'usine d'urée vers un système de condensation,
ledit système de condensation comprenant une sortie de liquide en communication fluide avec la chambre pour échange de chaleur indirect ;
- 15 - et la fourniture d'une ligne d'écoulement de gaz à partir de la section de séparation de dégagement gazeux de la zone de production de mélamine vers le système de condensation, dans lequel ledit système de condensation est configuré pour soumettre la vapeur de la section de séparation liquide/gaz de l'usine d'urée et le dégagement gazeux de mélamine à une condensation combinée dans un échange de chaleur indirect avec le courant d'urée aqueuse.

20 **14.** Procédé d'augmentation de la capacité d'usine de la zone de production de mélamine d'une installation préexistante pour la production intégrée d'urée et de mélamine, ladite installation comprenant une zone de production d'urée et une zone de production de mélamine ; la zone de production d'urée comprenant une section de synthèse d'urée comprenant un réacteur et un épurateur, et une section de recirculation de carbamate comprenant une entrée pour

25 une solution d'urée aqueuse épurée et une section de séparation liquide/gaz ;
la zone de production de mélamine comprenant une section de synthèse de mélamine et une section de séparation de dégagement gazeux,
le procédé comprenant

- 30 - l'expansion de la capacité de synthèse de mélamine de la section de synthèse de mélamine ;
- l'addition d'un concentrateur à la zone de production d'urée,
ledit concentrateur comprenant une chambre d'évaporation pour du liquide à chauffer et à faire évaporer,
ladite chambre d'évaporation comprenant une sortie de gaz pour du liquide évaporé et étant en communication d'échange de chaleur avec une chambre pour échange de chaleur indirect ;
- 35 - la fourniture d'une ligne de transport pour l'introduction de liquide à partir de la section de séparation liquide/gaz de l'usine d'urée vers ladite chambre d'évaporation ;
- la fourniture d'une ligne d'écoulement de gaz à partir de la section de séparation liquide/gaz de l'usine d'urée vers un système de condensation,
ledit système de condensation comprenant une sortie de liquide en communication fluide avec la chambre pour échange de chaleur indirect ;
- 40 - et la fourniture d'une ligne d'écoulement de gaz à partir de la section de séparation de dégagement gazeux de la zone de production de mélamine vers le système de condensation,

45 dans lequel ledit système de condensation est configuré pour soumettre la vapeur de la section de séparation liquide/gaz de l'usine d'urée et le dégagement gazeux de mélamine à une condensation combinée dans un échange de chaleur indirect avec le courant d'urée aqueuse.

15. Utilisation d'un procédé selon l'une quelconque ou les deux des revendications 13 et 14 pour restructurer une installation pour la production intégrée d'urée et de mélamine.

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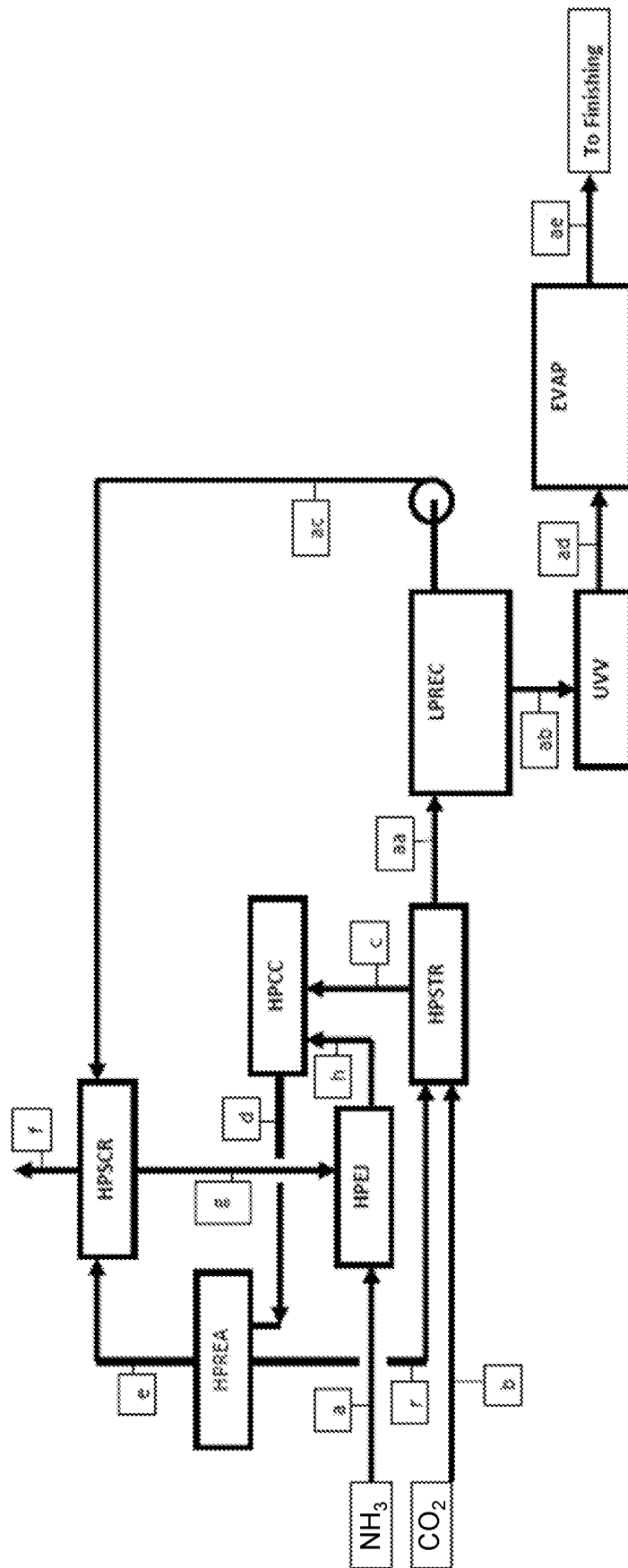


FIG. 1

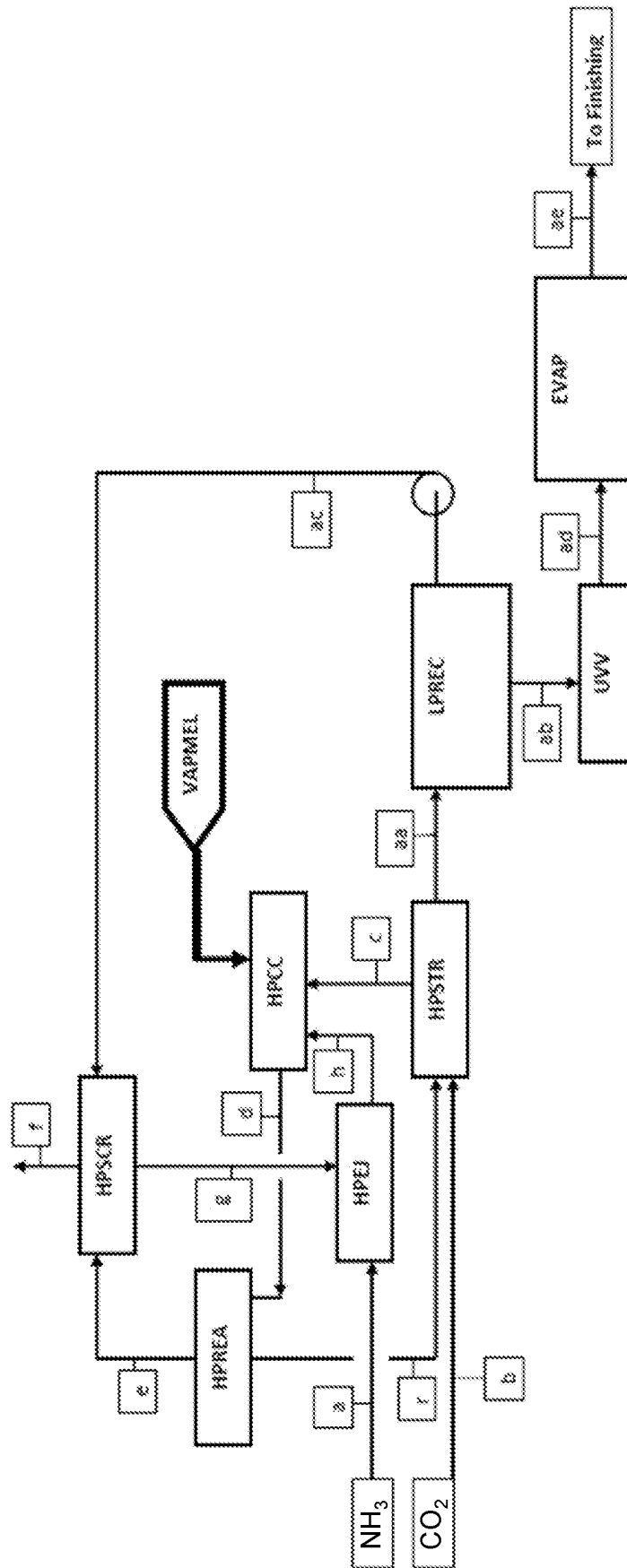


FIG. 2

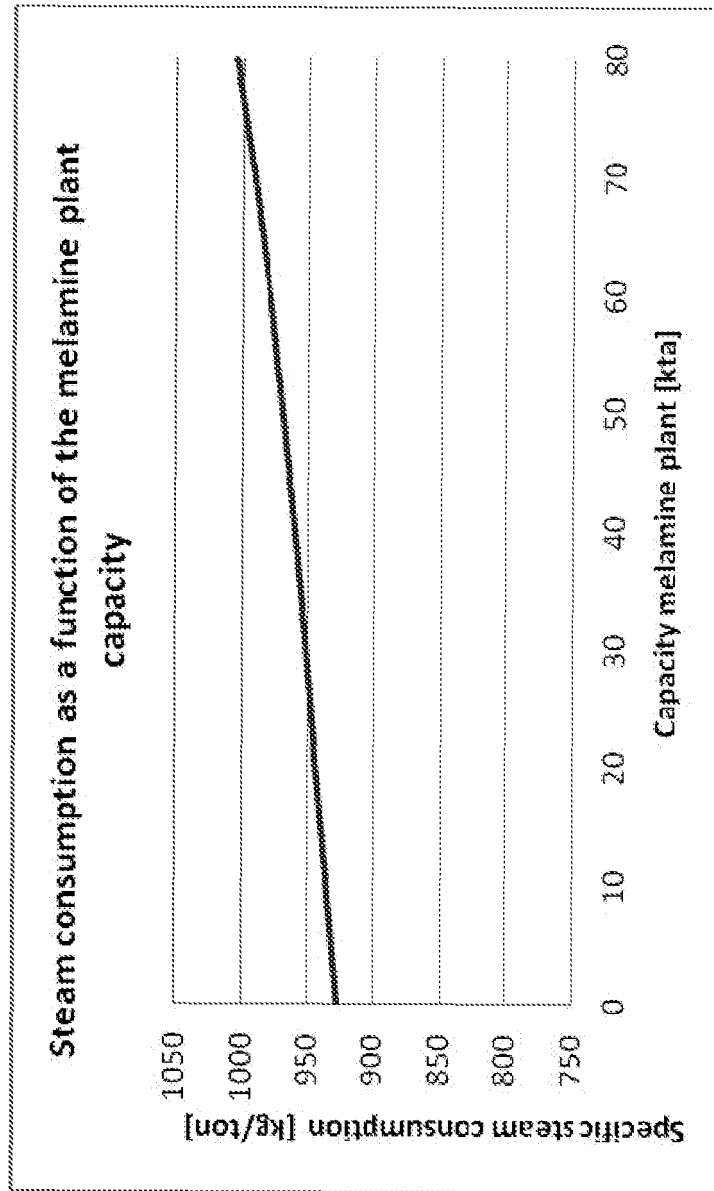


FIG. 3

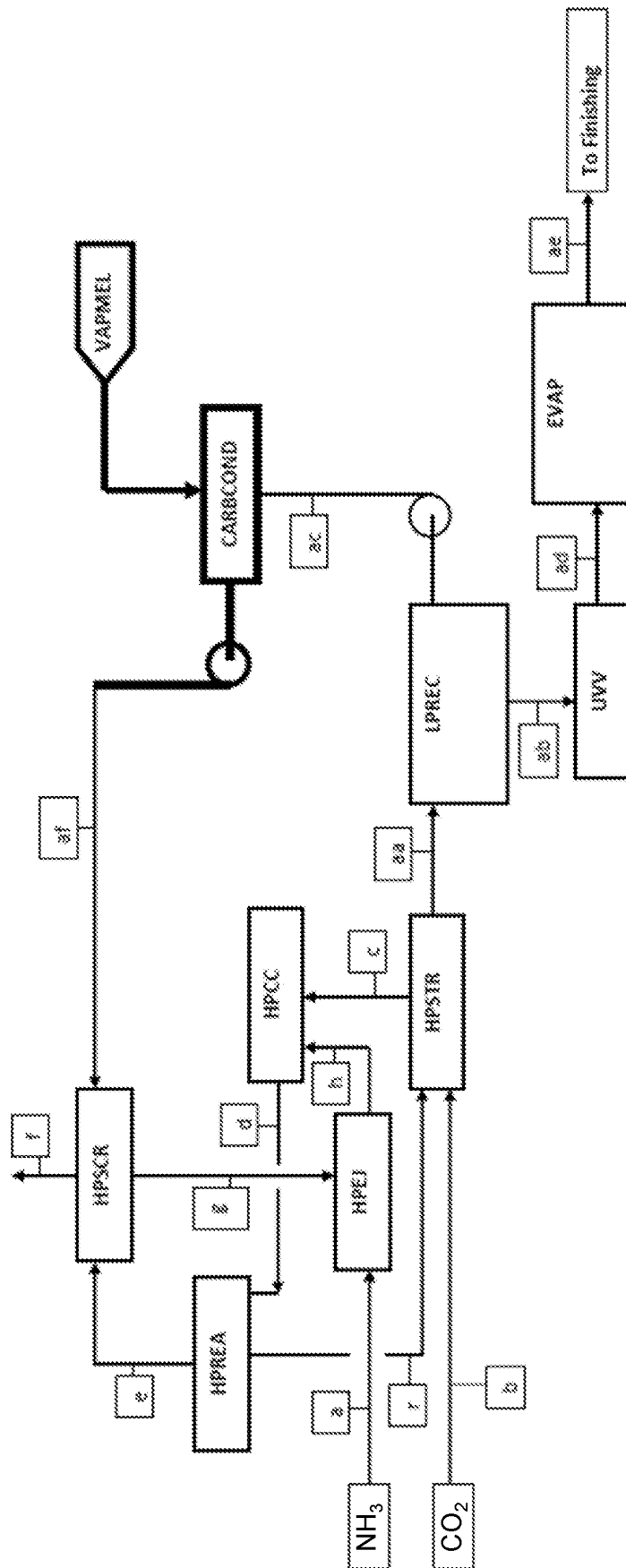


FIG. 4

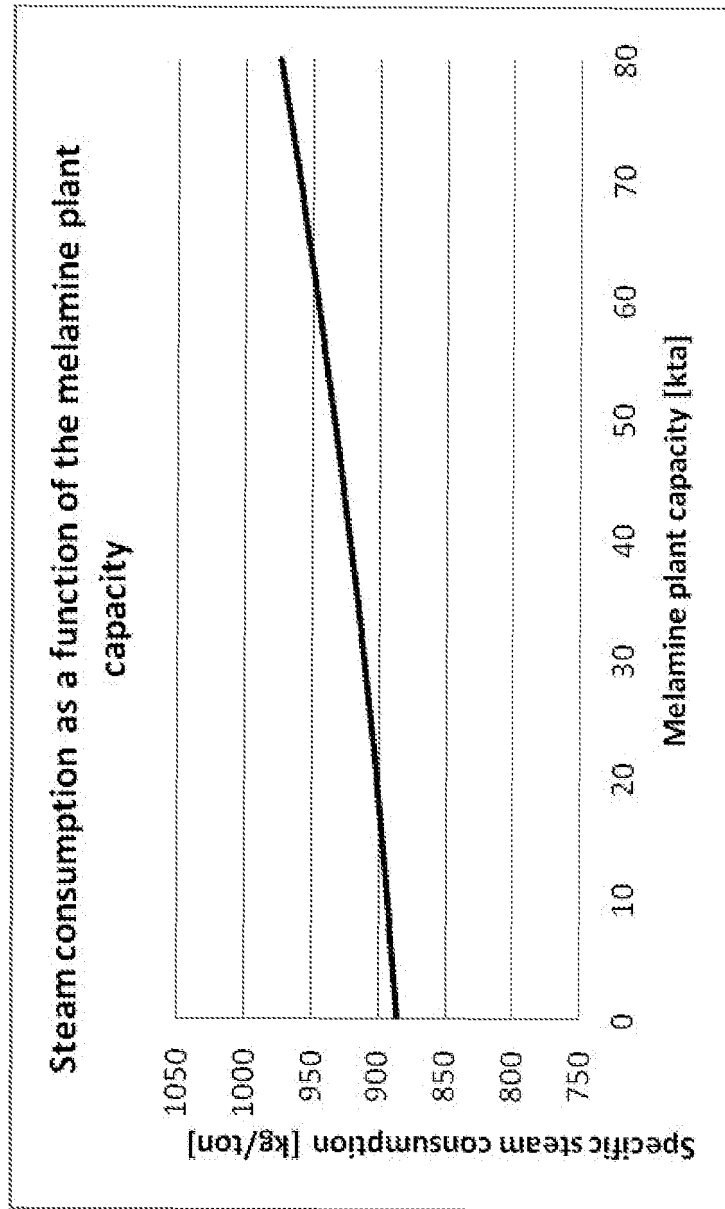


FIG. 5

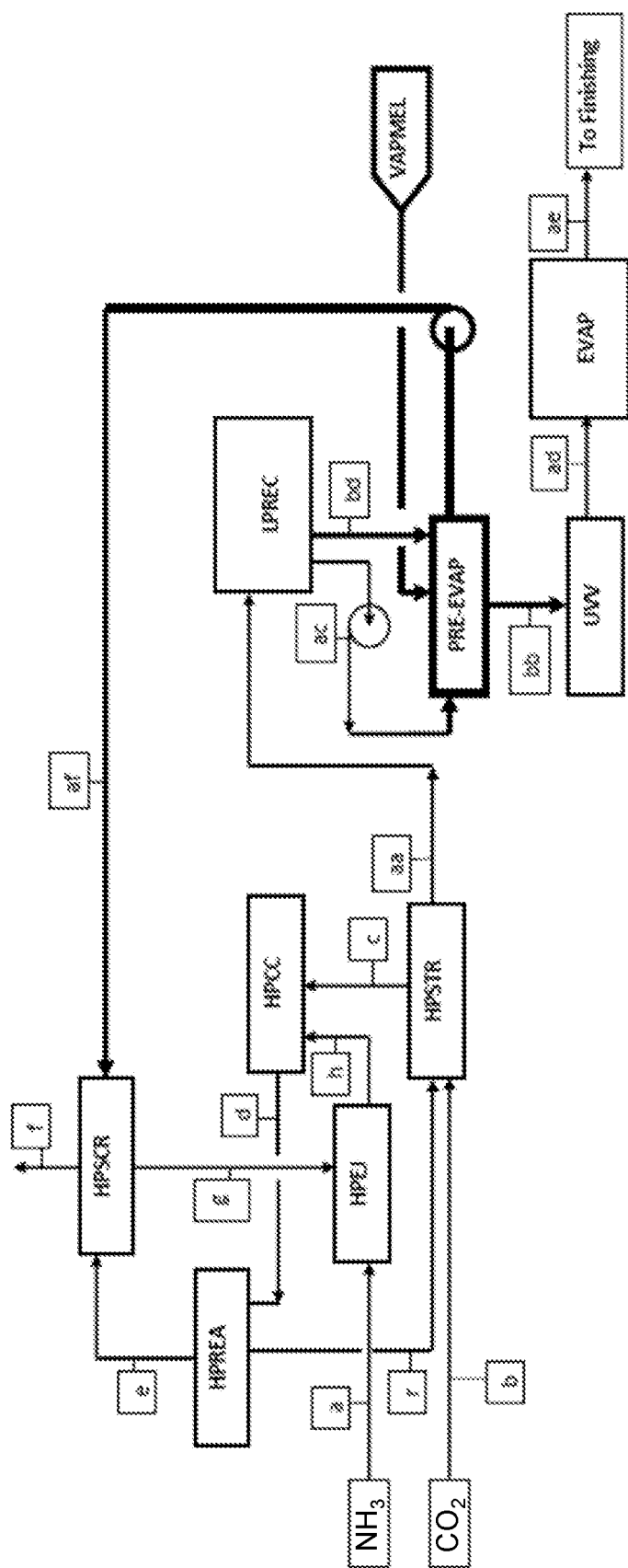


FIG. 6

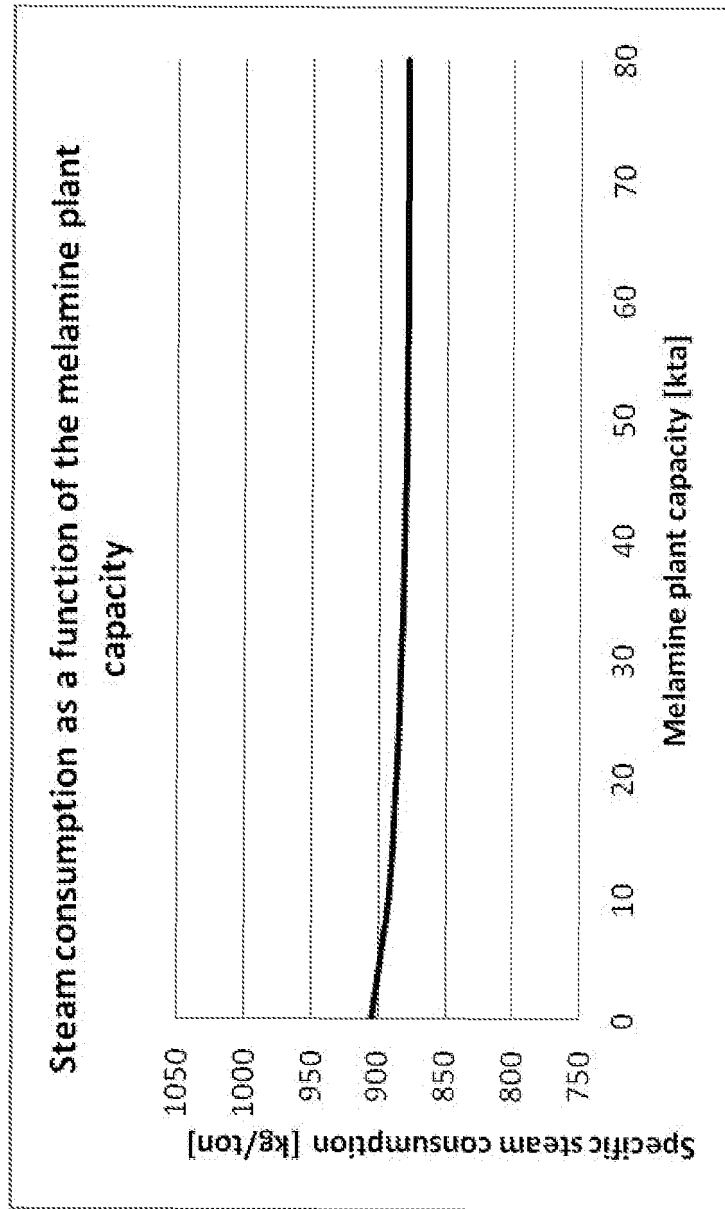


FIG. 7

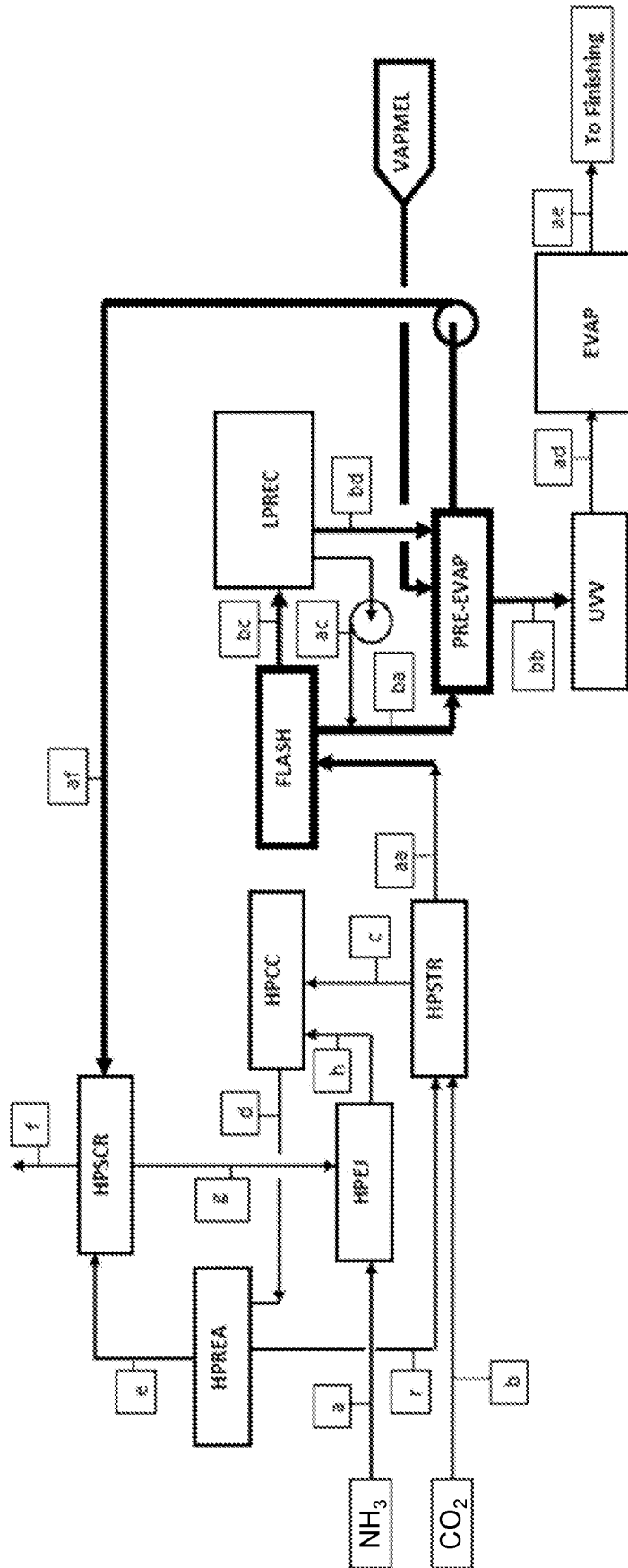


FIG. 8

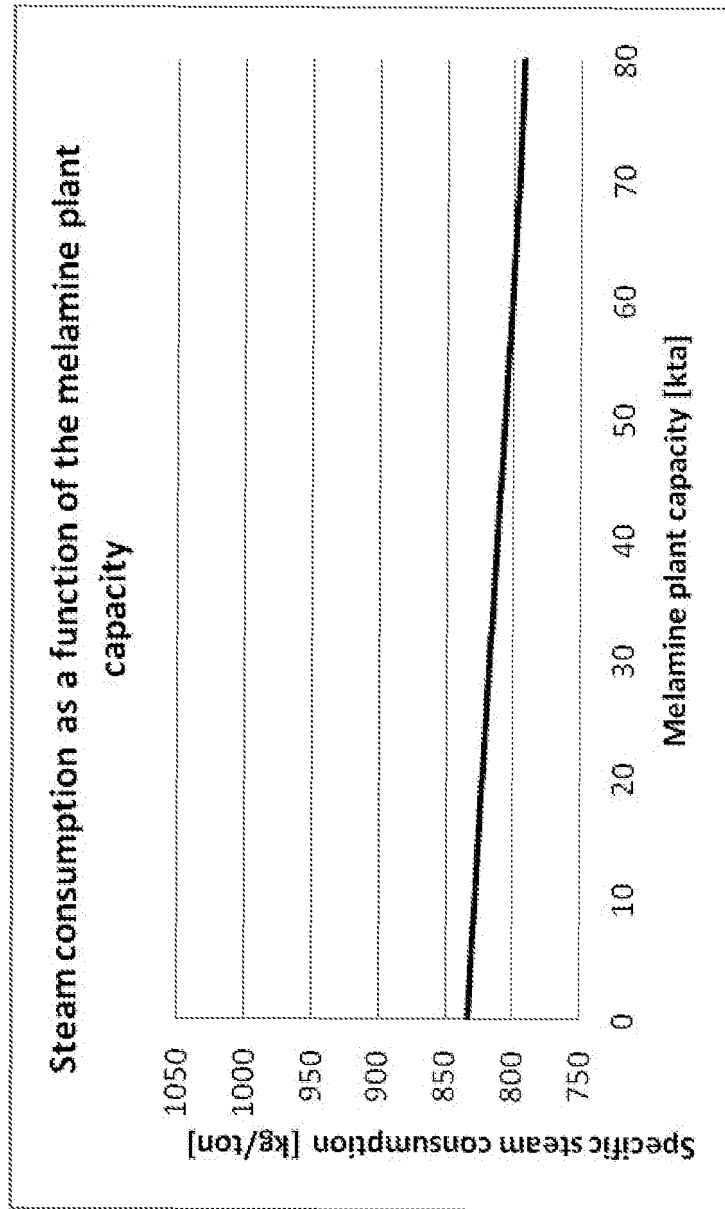


FIG. 9

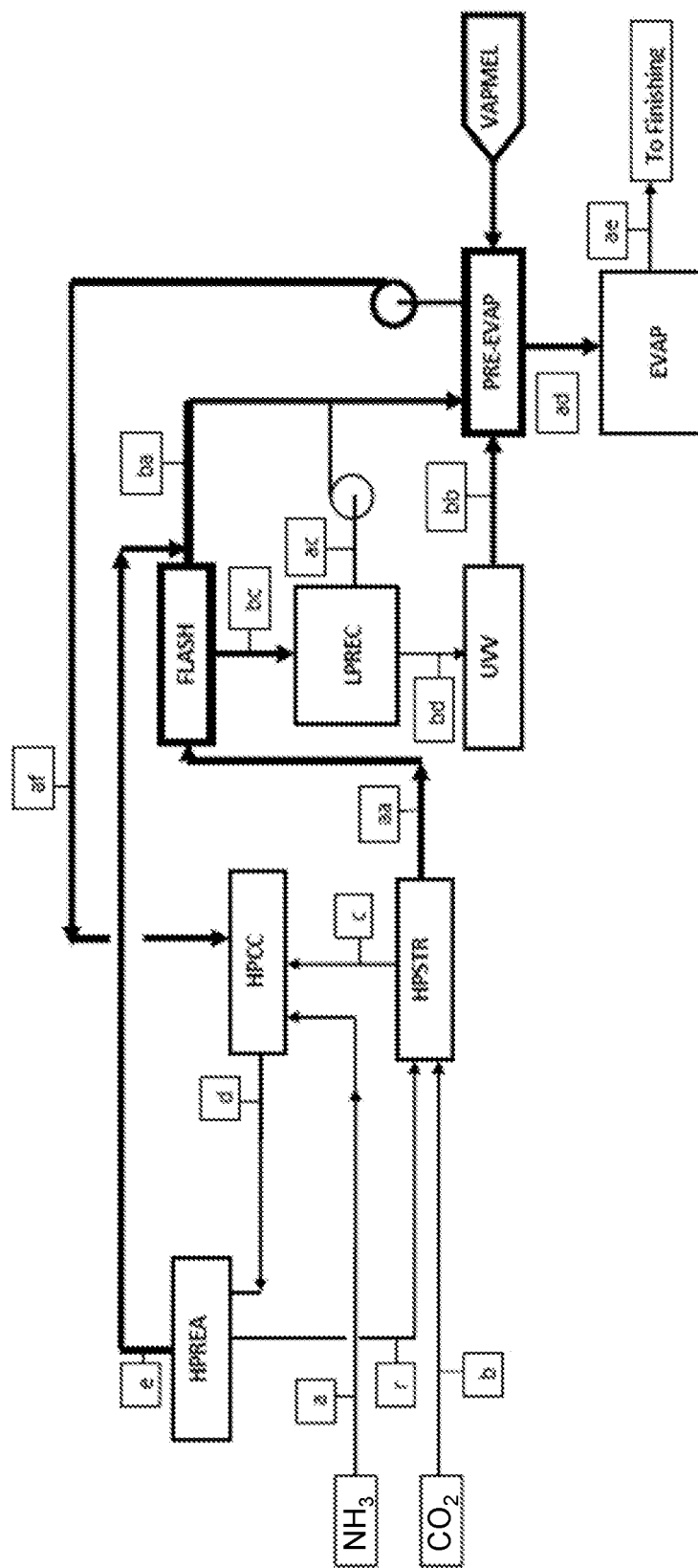


FIG. 10

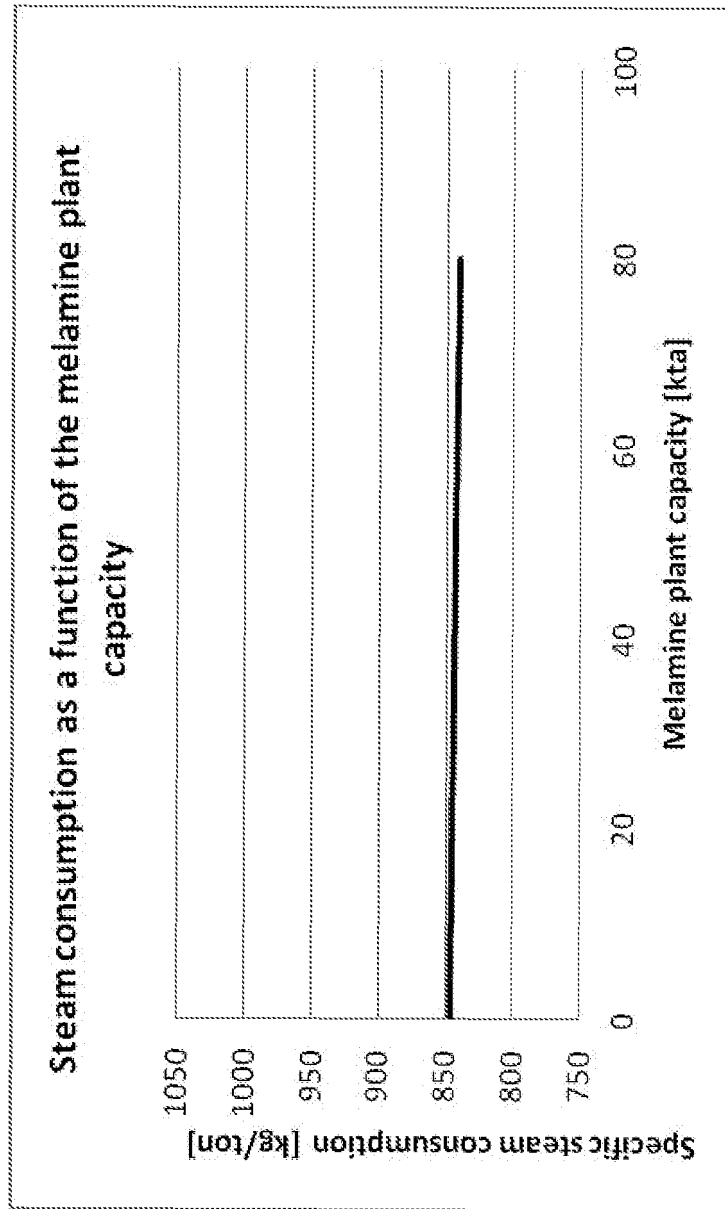


FIG. 11

REFERENCES CITED IN THE DESCRIPTION

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